DOCUMENT RESUME

ED 116 637 IR 002 877

AUTHOR	Smith, Edgar A.
TITLE	Quality Assurance of Media Devices and Courseware.
INSTITUTION	Air Force Human Resources Lab., Lowry AFB, Colo. Technical Training Div.
REPORT NO	AFHRL-TR-75-37
PUB DATE	Oct 75
NOTE	30p.
EDRS PRICE	MF-$0.76 HC-$1.95 Plus Postage
DESCRIPTORS	*Audiovisual Aids; *Films; Government Publications; Instructional Films; Performance Specifications; *Quality Control; *Slides; *Tape Recordings; Visual Aids

ABSTRACT

A quality assurance program is outlined that could be employed during the development of prenarrated sound/slide instructional packages. The characteristics described were selected to be both: (1) important to instruction and (2) capable of being measured objectively. These criteria were selected in order to develop a program that would be suitable for incorporation into contracts where a training program would be developed by a commercial agency and delivered to a United States Air Force training base. It is recommended that the procedures also be incorporated into programs in which the instructional material is being developed in-house. Particular attention is paid to the essentiality of being able to update and revise the training programs. (Author/EMH)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

AFHRL-TR-75-37

AIR FORCE

HUMAN RESOURCES

LABORATORY

QUALITY ASSURANCE OF MEDIA DEVICES AND COURSEWARE

By

Edgar A. Smith

TECHNICAL TRAINING DIVISION
Lowry Air Force Base, Colorado 80230

October 1975
Interim Report for Period December 1974 – April 1975

Approved for public release; distribution unlimited.

ED116637

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

IS DOCUMENT HAS BEEN REPRO-
CED EXACTLY AS RECEIVED FROM
E PERSON OR ORGANIZATION ORIGIN-
ING IT. POINTS OF VIEW OR OPINIONS
ATED DO NOT NECESSARILY REPRE-
NT OFFICIAL NATIONAL INSTITUTE OF
UCATION POSITION OR POLICY

IR 008 877

2

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

NOTICE

When US Government drawings, specifications, or other data are used for any purpose other than a definitely related Government procurement operation, the Government thereby incurs no responsibility nor any obligation whatsoever, and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise, as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use, or sell any patented invention that may in any way be related thereto.

This interim report was submitted by Technical Training Division, Air Force Human Resources Laboratory, Lowry Air Force Base, Colorado 80230, under project 1121, with Hq Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235.

This report has been reviewed and cleared for open publication and/or public release by the appropriate Office of Information (OI) in accordance with AFR 190-17 and DoDD 5230.9. There is no objection to unlimited distribution of this report to the public at large, or by DDC to the National Technical Information Service (NTIS).

This technical report has been reviewed and is approved.

MARTY R. ROCKWAY, Technical Director
Technical Training Division

Approved for publication.

HAROLD E. FISCHER, Colonel, USAF
Commander

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: AFHRL-TR-75-37	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): QUALITY ASSURANCE OF MEDIA DEVICES AND COURSEWARE	5. TYPE OF REPORT & PERIOD COVERED: Interim, December 1974 – April 1975
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s): Edgar A. Smith	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Technical Training Division, Air Force Human Resources Laboratory, Lowry Air Force Base, Colorado 80230	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 11210702
11. CONTROLLING OFFICE NAME AND ADDRESS: Hq Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235	12. REPORT DATE: October 1975
	13. NUMBER OF PAGES: 30
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

The use of brand names in this report is for descriptive purposes only. Use of brand names does not imply an endorsement of the product by the Air Force nor an endorsement of this publication by the firm.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

learning center
educational facilities
media
quality assurance
training methods
individualized instruction
training technology
automated instruction
photography
audio cassettes
recorded audio

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The intent of this publication is to outline one quality assurance program that could be employed during the development of prenarrated sound/slide instructional packages. The characteristics described were selected to be both: (a) important to instruction and (b) capable of being measured objectively. These criteria were selected in order to develop a program that would be suitable for incorporation into contracts where a training program would be developed by a commercial agency and delivered to a USAF training base. It is recommended that the procedures also be incorporated into programs in which the instructional material is being developed in-house. Particular attention is paid to the essentiality of being able to update and revise the training programs.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

SUMMARY

Problem

The use of prenarrated slide sequences in training programs is becoming common within many DoD agencies. These are particularly prevalent in learning centers and other individual instruction situations. Whether developed locally or obtained through a contractual effort, there is a need to institute quality assurance programs to verify that the physical quality of the visuals and recording are adequate to convey the instructional content.

Approach

While good physical quality will not overcome poor content, poor photography and recording can interfere with the presentation of content in even the best training program. AFM 50-2 is intended to assure acceptable content; this publication suggests a procedure to assure that the visuals and recordings are adequate to present that content. Particular attention is paid to production techniques that facilitate updating and revision of programs.

Results

A series of inspections and tests are described that can be employed to objectively evaluate some of the more relevant parameters of visuals and recordings. Parameters evaluated include the format of the visuals as well as the density, color balance, contrast ratio, cropping, and resolution of the resultant slides. The recorded narrative material is evaluated in terms of frequency response, distortion, and noise. The control impulses are evaluated in terms of frequency, duration, shape, and amplitude. All evaluations are based on objective measurements that are repeatable and do not require extensive training. While two test instruments are required, interim procedures are suggested that may be employed until such instrumentation is obtained.

Discussion

The intent of this publication is to outline one quality assurance program that could be employed during the development of prenarrated sound/slide instructional packages. The characteristics described were selected to be both: (a) important to instruction and (b) capable of being measured objectively. These criteria were selected in order to develop a program that would be suitable for incorporation into contracts where a training program would be developed by a commercial agency and delivered to a USAF training base. It is recommended that the procedures also be incorporated into programs in which instructional material is being developed in-house. Particular attention is paid to the essentiality of being able to update and revise the training programs.

TABLE OF CONTENTS

		Page
I.	Introduction	5
II.	Selection and Acceptance of Devices	5
	Responsibilities of Contract Monitor	5
	Functional Systems	6
	Acceptance Testing	6
III.	Selection and Acceptance of Cassettes and Film	6
	Film	6
	Cassettes	7
	Storage Cases	7
IV.	Recording and Duplication of Audio	7
	Separate Track System–ANSI PH 7.4	7
	Quality Assurance Tones	7
	Control Cues	8
	Recording Level–Program Audio	12
	AFHRL/TT Assistance	12
	Duration of Quality Assurance Program	13
V.	Preparation and Duplication of Visuals	13
	8 X 10 in. Captioned Photos	13
	Types of Visuals	14
	Test Card	15
VI.	Summary	19
	Devices	19
	Cassettes and Film	19
	Audio	19
	Visuals	19
	Implementation of Program	19
	Assistance in Starting	20
References		21
Appendix A. Captioned Photos as a Production Technique		23

LIST OF ILLUSTRATIONS

Figure		Page
1	XY plots of serial duplication of test tones - duplicator A	9
2	XY plots of serial duplication of test tones - duplicator B	10
3	Oscilloscope traces of four cue signals	11
4	Test chart - quality assurance	16
A-1	Basic format of 8 x 10 cards	25
A-2	Caption and red arrow added to 4 x 5 black and white photo	25
A-3	Lettering placed on 8 x 10 photo cropped to 6 x 8 or mounted full size	26
A-4	Lettering or photographically enlarged typed copy	26

QUALITY ASSURANCE OF MEDIA DEVICES AND COURSEWARE

I. INTRODUCTION

At the present time, USAF and other DoD agencies are developing training programs that include prenarrated sound/slide or prenarrated filmstrip packages. The intent of this publication is to outline one quality assurance program that could be employed during the development of these packages. The characteristics described were selected to be both: (a) important to instruction and (b) capable of being measured objectively. These criteria were selected in order to develop a program that would be suitable for incorporation into contracts where a training program would be developed by a commercial agency and delivered to a USAF training base.

The information here is intended to supplement such documents as AFM 50-2 which deal with developing the instructional packages. Therefore, subject matter content is not considered in this publication. Attention here is restricted to evaluating some of the physical characteristics of the media package. While good physical quality will not overcome poor content, poor photography and recording can interfere with the presentation of content in even the best training program. AFM 50-2 is intended to assure acceptable content; this publication suggests a procedure to assure that the visuals and recordings are adequate to present that content.

Topics discussed in this report are:

Selection and Acceptance of Devices

Selection and Acceptance of Cassettes and Film

Recording and Duplication of Audio (including control impulses)

Preparation and Duplication of Visuals

Summary

Appendix A: Captioned Photos Production Technique

II. SELECTION AND ACCEPTANCE OF DEVICES

As a rule, mediated technical training usually requires the projection of a slide or filmstrip onto a rear projection screen with the advance of the visuals controlled by the cassette. In most cases, program stop is a requirement since the training programs usually require student activity of some type involving his hands. A review feature is desirable. It must be stressed, however, that these are suggested average conditions. Careful consideration of specific applications may indicate radically different requirements. The essential element is to utilize the instructional system development (ISD) process to obtain a match between instructional requirements and device capabilities.

Responsibilities of Contract Monitor

If the instructional program is to be produced by a contractor, then these elements become more critical for the contract monitor. He must assure that the devices obtained are appropriate for USAF use. This includes classroom reliability and usability. It also involves maintainability including availability of manuals, expendables and parts. The initial shipment to a base must include maintenance manuals and an assurance that trained maintenance personnel are on hand and that the parts required are available. While this may sound so obvious that the contract monitor may decide to delay specific action on it, there are many devices in our inventory today for which there are no schematics, manuals, or replacement parts. Costs must be anticipated over the lifetime of the instructional program. The device that is cheapest initially may not prove to be economical over an extended period if it cannot be maintained.

In considering the classroom needs, particular note should be made of the viewing area required (will the student move about). These needs vary considerably. There is no one screen that is suitable for all uses. Wide angle screens cost in terms of heat, noise, and energy. Highly directional screens may limit movement at the work bench.

To summarize, verify that all devices meet the usability requirements of the ISD analysis, the durability requirements of the classroom, and the maintainability requirements of the repair technicians. The latter includes availability of parts, manuals, schematics, and test procedures.

Functional Systems

A consideration that needs to be emphasized repeatedly is the requirement for securing a functional system rather than devices. For example, if presentation device A is selected, can you develop and maintain the software? Instances are not uncommon in which organizations have obtained projectors or monitors without also obtaining cameras and duplicators. Presentation devices require development devices and these, in turn, require maintenance and quality assurance devices and procedures. Only a total system integrated into ongoing USAF activities can function efficiently and effectively.

Acceptance Testing

Acceptance testing of devices is essential. All hardware must be tested on receipt in order to assure the repair and/or replacement of defective or damaged devices under the provisions of the warranty. The purchase price includes payment for the warranty. If it is not used, USAF is paying for something that it does not receive. Do not assume that a device sealed in a box is functionally acceptable. A tape recorder is a device that reproduces sound, not a box labeled "Recorder." You have not received a device until it is in working order. It is not uncommon to have more than half of a shipment defective on receipt. This is often true even of equipment obtained from the most reliable of manufacturers. They have little or no control over shipments after they leave the factory. Most manufacturers seriously appreciate hearing from you if a device is unsatisfactory. They need to be able to trace and correct the fault.

Often what appears to be a fault in a device can be traced to "operator error." Obtaining assistance as soon as possible helps prevent material damage. Also, the real fault may be hidden or in some other part of the system. For example, if a recorder does not advance the slides, the fault may be in the recorder, but it could also be in the projector, the cables, in the tape or in the duplicator that made the tape.

This requirement for acceptance testing is particularly true when equipment is purchased by a contractor for delivery to a base.

AFHRL-TR-74-101 "Acceptance Inspection for Audio Cassette Recorders," may provide a starting point for developing an acceptance testing program. It must be modified to be made compatible with specific situations and compatible with the base involved.

III. SELECTION AND ACCEPTANCE OF CASSETTES AND FILM

Film

If the contractor is to furnish film, the major concern would be in terms of processing requirements. If the USAF base is to do the processing, then the film must be compatible with base facilities. Normally this would be E-4 processing but this can vary. The length of film that can be processed is also a consideration. Many bases are equipped to process color film only in 36 exposure lengths. This is a limitation especially when processing large volumes of slides and particularly when dealing with filmstrip. Making arrangements to have Aerospace Audio Visual Services (AAVS), Norton AFB, CA, do the processing should be considered. The film must also be compatible with the lighting used. This is a concern primarily in that not all films are available in all lengths. As an example, tungsten lighting is usually used in copy cameras, but suitable film may not be available in 36 exposure rolls. This length may be required either by the camera or the processor. The gamma characteristics of the film are also essential, especially if duplication is involved.

Fortunately these problems are relatively easy to handle. They tend to be non-recurring. Once a suitable film is selected, little problem will be encountered unless someone changes a procedure. It is essential, however, to select one particular film and stick with that brand and type. What appears to be a minor variation to one person can be a major concern to another. If procurement obtains what appears to be an acceptable substitute, it may be completely unusable if it requires chemistry that is not available. Kodak Ektachrome X 5027 in 36 exposure daylight cassette, Kodak Ektachrome EF Film 5242 (Tungsten) or Kodak Ektachrome MS Film 5256 (daylight) for original copy camera work, and Kodak Ektachrome Slide Duplicating Film 5038 for duplicates is a recommended film combination.

Cassettes

The selection of cassettes is more difficult. It should be specified that the tapes be capable of recording 100 thru 8kHz signal input with 1 volt rms with:

a. less than 3dB variation plus or minus,

b. less than 3% harmonic distortion of 1 kHz signal,

c. less than 3dB fluctuation of 1kHz continuous tone,

d. and have at least 50dB signal to noise separation.

These characteristics are easily verified. Their importance is accentuated since these characteristics are cumulative over the full tape-record-duplicate-play system. Any distortion will build up to an unacceptable degree. The ultimate test must always be in terms of conveying information to the student, not specific meter readings along the way taken in isolation.

Physical characteristics. It would be possible to specify the physical characteristics of cassettes in terms of guides, rollers, tensile strength of tape, etc. but it would be difficult to justify and test all of these. One particular characteristic that is very difficult to specify is the amount of loose oxide that transfers to the play head during use. Fortunately, most desirable features on tape tend to go together; i.e., a good quality tape that meets the recording specifications given above also tends to have minimal build up, good tensile strength, and the like. It would appear to be adequate to specify that the tape should be the equivalent of Scotch AVC-60.

It is essential that an acceptable type of tape be selected initially and then used throughout the project. Attempting to use varying types of tape causes many problems in terms of bias adjustment of the recorders, duplication characteristics, etc.

Storage Cases

Some thought should be devoted to the selection of the cases the cassettes are stored in. If these are transparent, then the labeling is easier and they are less likely to be misfiled. Sleeve type containers are much easier to handle and more durable than those with hinged lids. If possible, a container that will hold both the cassette and the visuals should be used. This makes classroom administration more manageable.

IV. RECORDING AND DUPLICATION OF AUDIO (Including Control Impulses)

The recorded master received should be on 1/4-in. tape recorded at 7-1/2 ips. Half track recording is required. Each reel should be clearly labeled with the title, subject matter content, and running time. A written copy of the script that includes impulse notations must accompany the master and be filed with it. The receiving base is encouraged to make a sub-master from the true master but it is not recommended that this be required of the contractor.

Separate Track System—ANSI PH 7.4

The separate track system defined in ANSI PH 7.4 will be used in cassette recording. This has the audio information recorded on the lower track (tracks 1 and 2) and the cue tones for control of the visual advance and program stop recorded on the upper track (tracks 3 and 4). Both the 1/4-in. reel and the cassette are recorded for playback in one direction of tape travel only.

Quality Assurance Tones

Two quality assurance tones should be recorded at the end of every master. Each tone will be duplicated as part of each tape so that the test tones are subject to the same number and type of duplications as the narration. These tones will be used as primary sources of quality assurance specification. Each tone should be between 25 and 35 seconds long.

1,000 Hz Tone. The first tone shall be 1 kHz verified with an electronic counter and recorded at 0 dB with 1 volt rms input into radio/phone jack. When the master or any duplication to and including the ones intended for student use are played back, this tone is used to determine speed and distortion. Speed should be within 3% as determined by an electronic counter, or 6% if determined by an oscilloscope calibrated to within 3%. Neither the 2nd or 3rd harmonic should exceed 2% of signal. Flutter should not exceed 1% rms.

Signal to noise should exceed 50 dB. When the Mincom 6500 Recorder Test Set is available, a two minute composite signal generated by it should be substituted for the 1 kHz signal. This tone should be followed by a 30 second interval as detailed in the 6500 operating instructions. During initial phases of a program it may be desirable to use both sets of signals so that quality assurance can be accomplished with either set of test equipment.

White noise. The second reference tone is white noise recorded at –6 dB, or 0.58 volt rms. On play back, this tone is used to determine frequency response range. The required range for masters is 100 Hz thru 7 kHz. A more lenient 200 through 4 kHz could be accepted for final duplicates under certain conditions. The playback level should be plus or minus 3 dB within these limits.

This range was initially selected as being compatible with *Human Engineering Guide to Equipment Design* by Van Cott and Kinkade who in turn based their recommendations on *The Design of Speech Communication Systems* by L. L. Beranek. This was verified by subjective judgments while listening to recordings limited to various ranges. It is also compatible with equipment presently in use within USAF learning centers. Actual units tested do in fact have flat response from 100 thru 10 kHz. Thus, there is an agreement between equipment that is available, what research indicates is required, and subjective judgment of requirements. The judgment was included both to update research and also to make certain it was applicable within conditions where it is being applied.

Empirical data. To demonstrate the necessity for requiring quality assurance on audio material, the two test tones described above were recorded on a cassette and then serially duplicated; i.e., a first generation dupe was made from the master, a second generation dupe from the first, and so on until the fourth generation. The fourth generation was selected since in reality many of the tapes in use in classrooms can be expected to be third or fourth generation. For example, a prime base or contractor makes a training sequence and sends a copy to Hq, ATC. Air Training Command duplicates it again and sends copies to using bases. The using base then duplicates it for use in the classroom. The student in the classroom is listening (or attempting to listen) to a third or fourth generation tape.

The tapes mentioned above were used to generate plots on a XY plotter in order to obtain objective data for analysis. Figure 1 presents this information graphically. The upper line in each graph represents frequency response based on white noise. The lower line indicates response to 1 kHz pure tone, which indicates distortions and signal to noise ratio. Figure 2 presents comparable data on the same master duplicated on a different type and brand of duplicator.

As portrayed in No. 1 of Figure 1, the signals monitored while going into the master were as expected. The white noise indicated a flat response from 20 thru 10 kHz all within a band of plus or minus 1.5 dB. The 1 kHz test tone indicated no detectable second harmonic and less than 0.2% third. The signal to noise ratio was greater than 54 dB.

When the master cassette was played back the frequency range started to taper off at 8 kHz as is typical with this recorder but was still within the plus or minus three dB limits. Second harmonic had risen to one percent (–40 dB) and third to a little over two percent. The signal to noise ratio was still 54 dB. The readings from the duplicates indicated about the same distortion and signal to noise ratio. However, the frequency range deteriorated dramatically. To describe it, a band was taken that included all frequencies that had fallen off no more than 10 dB. For descriptive purposes this was termed the "usable range." For the first generation duplicate this range was 100 thru 6300 cycles which would probably be accepted. The second generation had further deteriorated to 150 to 5,000 cycles. The third generation had useful range of only 500 thru 4,500 cycles. The fourth indicated a useful range of only 1,500 thru 4,800 cycles which is well outside the limits recommended for USAF acceptance.

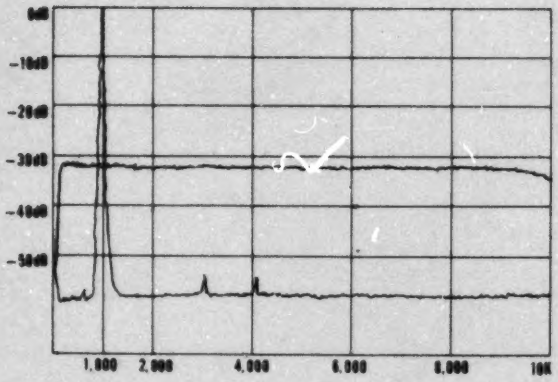
Control Cues

150 Hz and 1 kHz cues shall be used for primary control purposes. 150 Hz will be used for program stop. 1 kHz will be used for visual advance. Both frequencies shall be plus or minus 5%.

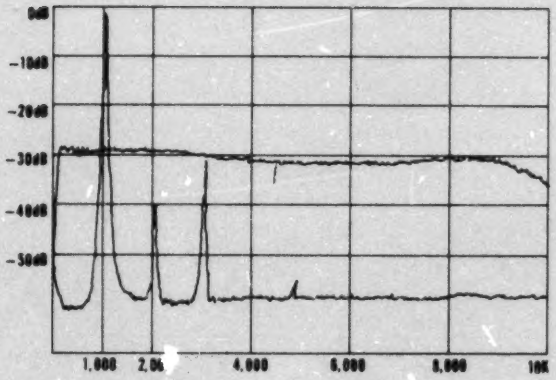
Duration, rise, time, distortion. Cue impluses shall be 0.45 plus or minus 0.07 seconds in duration. Impulses should be rectangular in form but may use up 10% of duration in rise time to reach maximum amplitude. Total harmonic distortion of cue shall not exceed 10%.

Empirical data. Figure 3 is a reproduction of oscilloscope traces made by four advance cue impulses.

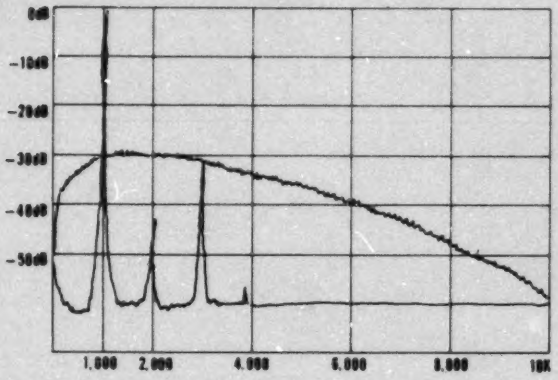
Number 1 is the trace from an advance cue signal on an original cassette recording generated, recorded, and played back on a Wolensak 2570AV. The reticle lines represent 0.1 second horizontally and



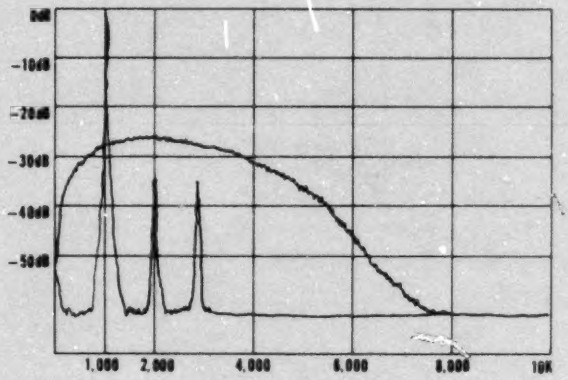
No. 1. Input



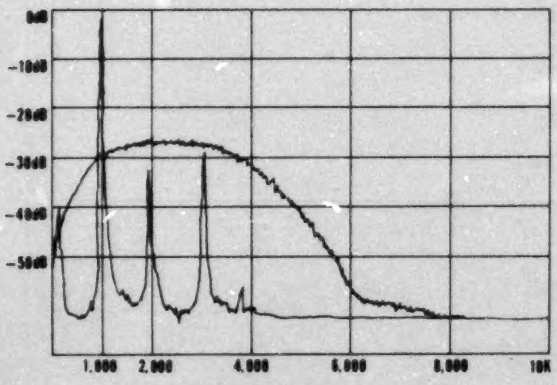
No. 2. Master Cassette



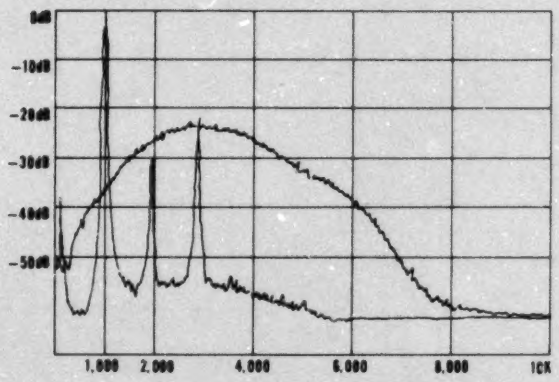
No. 3. 1st Generation Duplicate



No. 4. 2nd Generation Duplicate

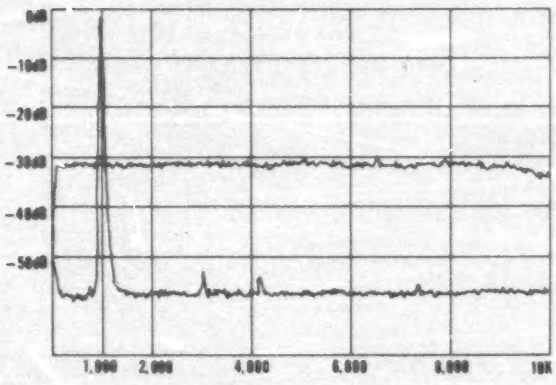


No. 5. 3rd Generation Duplicate

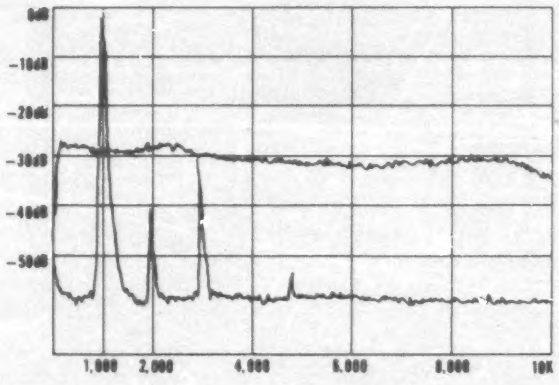


No. 6. 4th Generation Duplicate

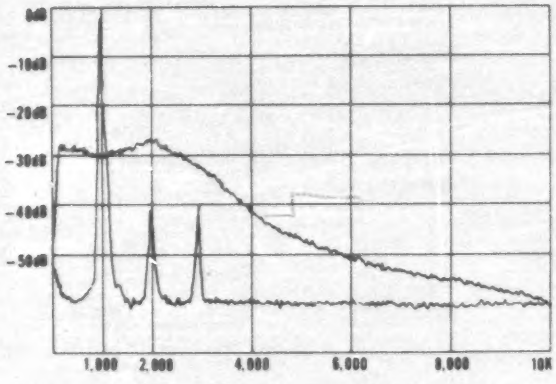
Figure 1. XY plots of serial duplication of test tones - duplicator A.



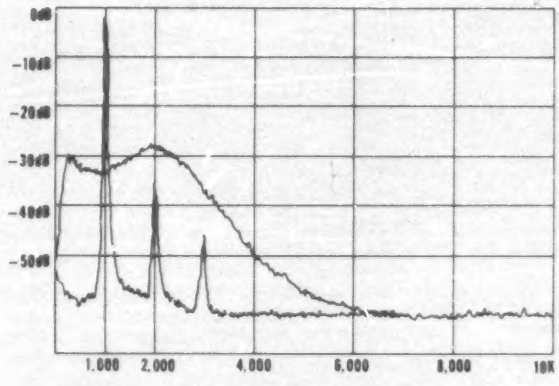
No. 1. Input



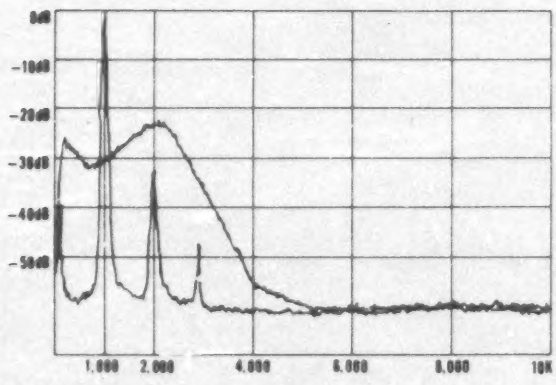
No. 2. Master Cassette



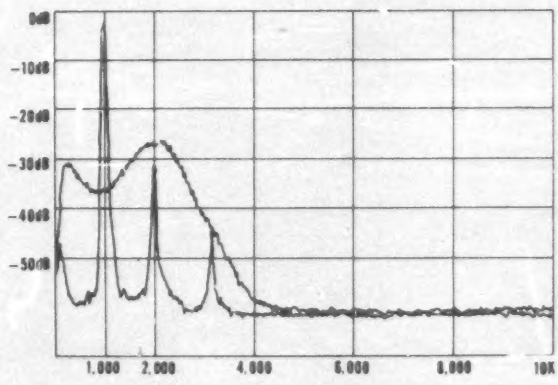
No. 3. 1st Generation Duplicate



No. 4. 2nd Generation Duplicate

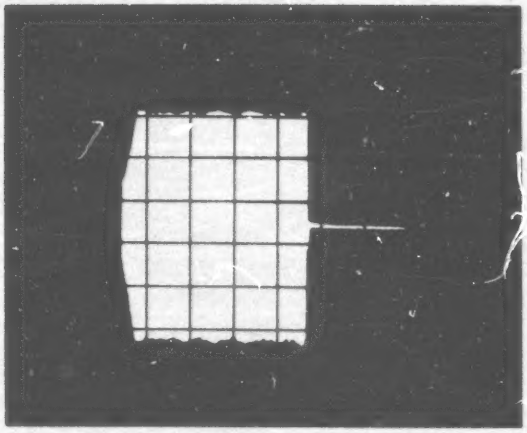


No. 5. 3rd Generation Duplicate

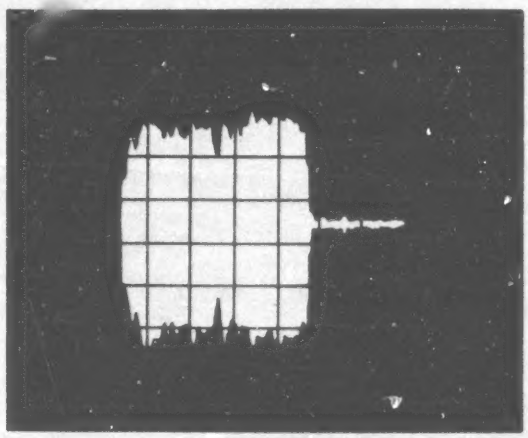


No. 6. 4th Generation Duplicate

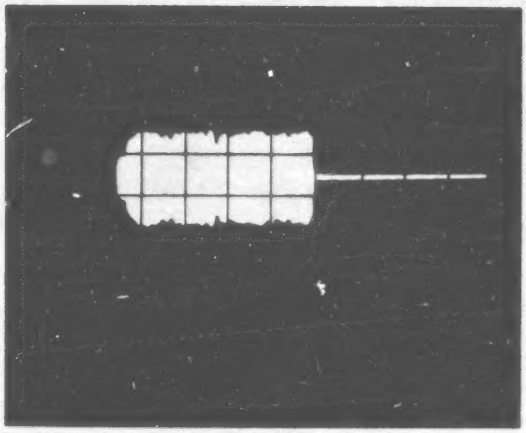
Figure 2. XY plots of serial duplication of test tones - duplicator B.



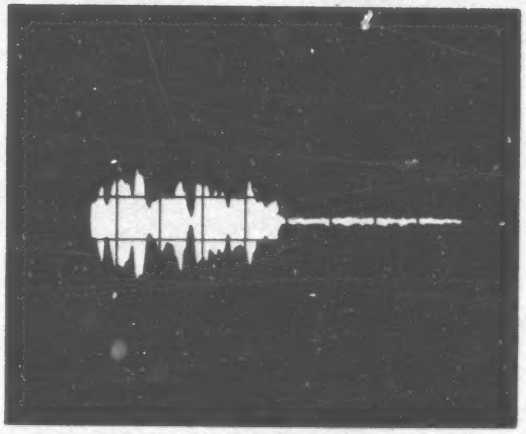
NO 1. ORIGINAL



NO 2. ACCEPTABLE



NO 3. WEAK



NO 4. UNACCEPTABLE

Figure 3. **Oscilloscope traces of four cue signals.**

1 volt vertically. It will be noted that this impulse was about 0.43 seconds in duration and about 5.3 volts peak to peak in amplitude. The slope on the leading edge reflects acceptable rise time. The upper and lower edges are relatively flat. The trailing edge is perpendicular.

Number 2 represents a cue signal from a duplicate cassette. This is presented to depict a "typical" acceptable duplicated cue impulse.

Number 3 shows a pattern that is acceptable in all aspects except amplitude. The playback device might respond to this signal but it might miss it on occasion.

Number 4 represents an unacceptable impulse. while the playback unit might respond to it, the reliability would be low. A large proportion of the unreliability seen in presentations can be traced to weak and/or deformed cue signals. In this instance, the required corrective action involved the duplicator, not the cassette players.

Time between cues. The minimum time between the start of two adjacent cues will be 1.5 seconds. There shall be a minimum of 2 seconds and a maximum of 5 seconds between the end of a stop cue and subsequent recorded material.

Recording Level–Program Audio

It is recommended that for recording the program audio a nominal mean recording level be –3 dB when a 1 volt rms (2.8 volt peak to peak) input results in 0 dB on the recording VU meter being used.

Cue Signals. In recording the cue signals, the recording should be such that when played back the resultant output measured with a calibrated oscilloscope at the sync output jack be approximately 5.7 volts peak to peak. Although tolerances of plus or minus 3 dB under ANSI PH 7.4 would allow this measurement to be between 4 and 8 volts, it is desirable to adjust recording level to produce a level as close as practicable to the 5.7 volt figures. The Wollensak 2570 AV may be used as a representative device to make data obtained consistent with existing material and with data obtained from the 6500 Recorder Test Set.

ANSI PH 7.4 levels. ANSI PH 7.4 recommends that program audio be recorded at "a nominal mean recording level of –6dB with reference to 250 nWb/m at 333 Hz. If the contractor has the equipment required to use this standard it would be acceptable. However, it will be the responsibility of the contractor to furnish verification procedures and equipment.

Initial impulses. High speed duplicators make it difficult to control the position of narrative material at the very beginning of a cassette. With some of the more common duplicators, a one second delay in duplication requires that the student wait 16 seconds for the narrative to begin. Conversely, starting the duplicator even a quarter of a second too early can eliminate the full introductory sentence and also get the slides out of synchronization with the narrative. The Aerospace Audio Visual Service (Norton AFB) suggests placing an image advance impulse followed by a program stop impulse at the beginning of each tape. This enables the student to place the cassette and filmstrip in the device and activate it. The two impulses accomplish several things. One, they verify the functioning of the equipment. Two, they advance the visuals to the title image which confirms the subject matter area. This image can also contain a notation of all materials or equipments that are required for the completion of the lesson. Third, this advances the cassette to the beginning of the actual instructional narrative so that the instruction starts immediately after the student depresses the start button. This suggestion should be followed. No matter how much care is taken in duplicating cassettes, between the 8 to 10 second leader and the music or blank tape that must be left to avoid omissions due to duplication, there is a very annoying wait for the instruction to start. With these impulses, at least the student could attend to something else while the recorder is running in to the impulses.

AFHRL/TT Assistance.

If the initial shipment of tapes is received prior to the establishment on the base of a quality assurance section with adequate test and evaluation equipment, it may be possible to have samples tested by Technical Training Division, Air Force Human Resources Laboratory (AFHRL/TTT). If so, it would be desirable to contact this organization to make specific arrangements. Point of contact:

AFHRL/TT

Lowry AFB, CO 80230

or 394-2954 (AV 926-2954)

Duration of Quality Assurance Program

The quality assurance program should continue throughout the life of the training program. Consequently, all contract requirements should result in deliverable equipment, material, and procedures that can be utilized on a continuing basis. For example, the quality should also be assured of all tapes duplicated by the base after the expiration of the contract. To expedite this, the procedures required can be performed using the Model 6500 Recorder Test Set developed under government contract by the Mincom Division of 3M Company. This device should be made available to base quality assurance personnel either as part of the contract or as GFE. It is available under GSA Contract F05600-75-85950. The calibration of this device has been specifically modified to meet the USAF uses of prenarrated cassettes in instructional, as contrasted to research, situations. To obtain this modification, Specify Part No. 6500-0000-40, Catalog No. 83-5990-1651. The specifically calibrated unit provides for three levels of quality assurance. Level A is the minimally acceptable duplicate cassette. Level B is compatible with requirements for cassette masters. Level C would be compatible with 1/4-in. reel masters. Our DoD instructional model has the characteristics as shown in Table 1:

Table 1. **Model 6500 Recorder Test Set Characteristics**

Function	Recorder Type		
	A	B	C
Output	1 V RMS	1 V RMS	1 V RMS
Level (Input)	1 V RMS	1 V RMS	1 V RMS
Low Frequency	200 Hz	100 Hz	50 Hz
High Frequency	4 kHz	6.3 kHz*	10 kHz
Distortion	3%	3%	3%
Flutter	0.35% RMS	0.35% RMS	0.25% RMS
Signal-to-Noise	45 dB	45 dB	45 dB

*This is the "Azimuth Set" frequency. Azimuth may be verified as follows—while reproducing a "6.3kHz standard azimuth tape" into the 6500 select Recorder Type "B" and "HI F" and adjust the "REFERENCE SET" control for a mid-scale reading on the meter then adjust (per the recorder manufacturer's manual) head azimuth for a peak reading on the meter. This procedure gives a common azimuth reference for all recorders and minimizes machine-to-machine errors that can cause severe loss of high frequencies when inter-changing tapes.

V. PREPARATION AND DUPLICATION OF VISUALS

All visuals should be delivered as "Captioned Photos." (See appendix A for description of "Captioned Photo Technique")

8 X 10 in. Captioned Photos

All visuals should be approximately 8 X 10 in. on card stock, thick enough to avoid curling, and with a horizontal format. The image to be photographed should be located in the center of the card and should be approximately 6 inches high and 8 inches long. Adequate bleed area should be allowed. Particular attention should be paid to aspect ratio. It is entirely possible that the first versions of the instructional package will be presented in the form of 35 mm slides. These 24 X 36 mm images have a 2 X 3 aspect ratio. This requires that approximately 3/4 in. be cropped off of the top and/or bottom; i.e., the area photog-

raphed is 5-1/4 X 8 inches. Classroom and production considerations may require a change to filmstrip at a later date. Filmstrip has an 18 X 24 mm image or a 3 X 4 aspect ratio This requires the full 6 X 8 in. image be photographed. The probable change to filmstrip is also the justification of the insistence on horizontal images. This ratio is also used in video and motion pictures.

With a little forethought, the required border can be allowed. It is most important that all art be prepared in such a way that it can be copied either as a slide or as a filmstrip.

Master slides. It may appear superficially that master slides could be prepared and duplicated rather than the captioned photo. Our experience indicates that the card art is easier and cheaper in the long run. Dust and fingerprints are less bothersome with card art. Cropping and framing is much easier. Contrast and density are easier to control. Captioning and high-lighting with arrows and inserts are practical with card art. Most important, updating is considerably easier. There have probably been more programs abandoned due to inability to update material than for any other single reason. Card art facilitates updating considerably. The significant change here is the requirement of uniform size and format.

If slides are accepted in lieu of card art, first generation masters should be required. These should be duplicated immediately upon receipt at the receiving base without ever being projected. These master slides should be carefully preserved and used for duplication purposes only.

Placement of photographic area. The precise size and placement of the area to be photographed must be accurate enough to allow the entire sequence to be photographed without additional camera set-ups or adjustments. The first image will be placed under the copy camera. It will be positioned by guides on the camera or a movable jig. The camera will be focused and exposure adjustments set. All subsequent images within that sequence will be accomplished merely by inserting the next piece of card art and depressing the exposure button. No attention to focus, framing, or exposure will be required.

This consistency within a training sequence will not be required between sequences. For example, all of the images on the second sequence might be larger than those employed in the first sequence, however, all within the sequence would be the same size, position, and density.

Numbering of visuals. It is desirable that the projected image be numbered for identification and to aid the student in maintaining synchronization between visuals and audio. Updating may be facilitated by using a series of removable numbered cards. These are laid on the card art when it is photographed, then removed. Such numbering or other identification should be distinctive and in the same location on all frames within a series to avoid confusion with subject matter material.

Types of Visuals

In terms of the image being photographed, this may be lettering or graphics. However, considerable use may be made of photographs showing objects or procedures. Many times, black and white photos with colored arrows for enhancement are particularly suitable. Many times 4 X 5 or 5 X 7 prints may be used with captions summarizing the action shown. These captioned photos are particularly effective in terms of review and remedial instruction, especially of topics requiring step-by-step procedures.

Expanded description. An expanded description of the captioned photo technique and initial cost comparisons between it and other production techniques is provided in Appendix A.

Lettering size. While it is difficult or impossible to write specifications for the composition and lay-out of acceptable slides, there are some guides relevant to the lettering on narrative slides. Lettering should be limited to 6 lines, with a maximum of 26 characters to a line. On the card art, the minimum height of a letter would be 3/8 inch. One crude, but useful rule, is that all words on a slide should be readable with the unaided eye. It is important that minimum letter sizes be used only when necessary. Do not use the minimum size as a standard, it should be a minimum with the average lettering being considerably larger.

Types of visuals. The types of visuals and proportions of different types varies widely. The data in Table 2 might be used as an initial guide in most instances. (Text refers to illustrations copied from texts or other training material.)

Table 2. **Visual Materials Photographed**

Type	Percentage of Slides Used
Photos	60
Text	10
Graphics	15
Typed	15

Filmstrip format. If filmstrips are furnished by the contractor, they should follow this pattern:

a. The trimming of the leading edge of the film should be a straight cut located between the sprocket holes at 90° with the edge of the film.

b. The first 6 frames of the film should have the word "START" in large white block letters on a green background.

c. The next frame shall be a test image providing for measurement of density, color balance, contrast, resolution, and cropping (Test Card paragraph).

d. Information identifying the filmstrip should appear in the three frames following the "Test" frame.

e. A focus and framing image should be located no less than 12 frames from the cut leading edge.

f. The focus frame should include instructions about starting the program (i.e., START TAPE WITH THIS IMAGE ON THE SCREEN.)

g. The title frame (or first instructional frame) will be no less than the 14th frame from the leading edge of the film.

h. The distance from the end title to the end of the filmstrip should be at least equal in length to the circumference of the can in which it is stored to preclude damage to the picture portion if stored without rewinding.

i. The last two frames of the film before the cut edge should have the word "END" in large white block letters appearing in each frame with a red background.

Test Card

Quality assurance of the visuals may be accomplished through the use of a test card similar to Figure 4.

The upper portion of the card is a series of color bands used to portray the color saturation of the slide. Actually, this portion of the slide is more for subjective considerations than for objective measurement. As a result, a brightly colored image depicting the training program could be substituted.

Cropping. The wording across the center of the slide is to give a measurement of cropping. If the image is improperly copied, the initial letters will be omitted.

Resolution. The resolution chart used here is the USAF 1951 1 x chart made for USAF by W. and L.E. Gurley, Troy, New York (The comparable NBS chart could be substituted.) When the test chart is photographed using a 50 mm lens with the film plane 19 in. above the base, an adequate test of resolution is obtained.

The resolution chart is divided into four groups of test lines labeled −2, −1, 0 and 1. Within each group are sets of three horizontal and three vertical lines each set numbered 1 through 6. The measurement is made by noting the finest set that appears to be 3 separate lines. This may appear to be rather subjective and crude, but with practice very reliable measurements can be obtained in this way. A good quality 20X loupe is helpful in making the determination. However, even projecting the image in a carousel can be used since even those relatively crude lenses will resolve images with considerably more detail than are actually needed in instruction. For instructional purposes, the resolution of set 6 in series 0 is probably sufficient. We are routinely able to resolve set 6 of Group 1 (the finest) on slides when using a 20X magnifier and set 4

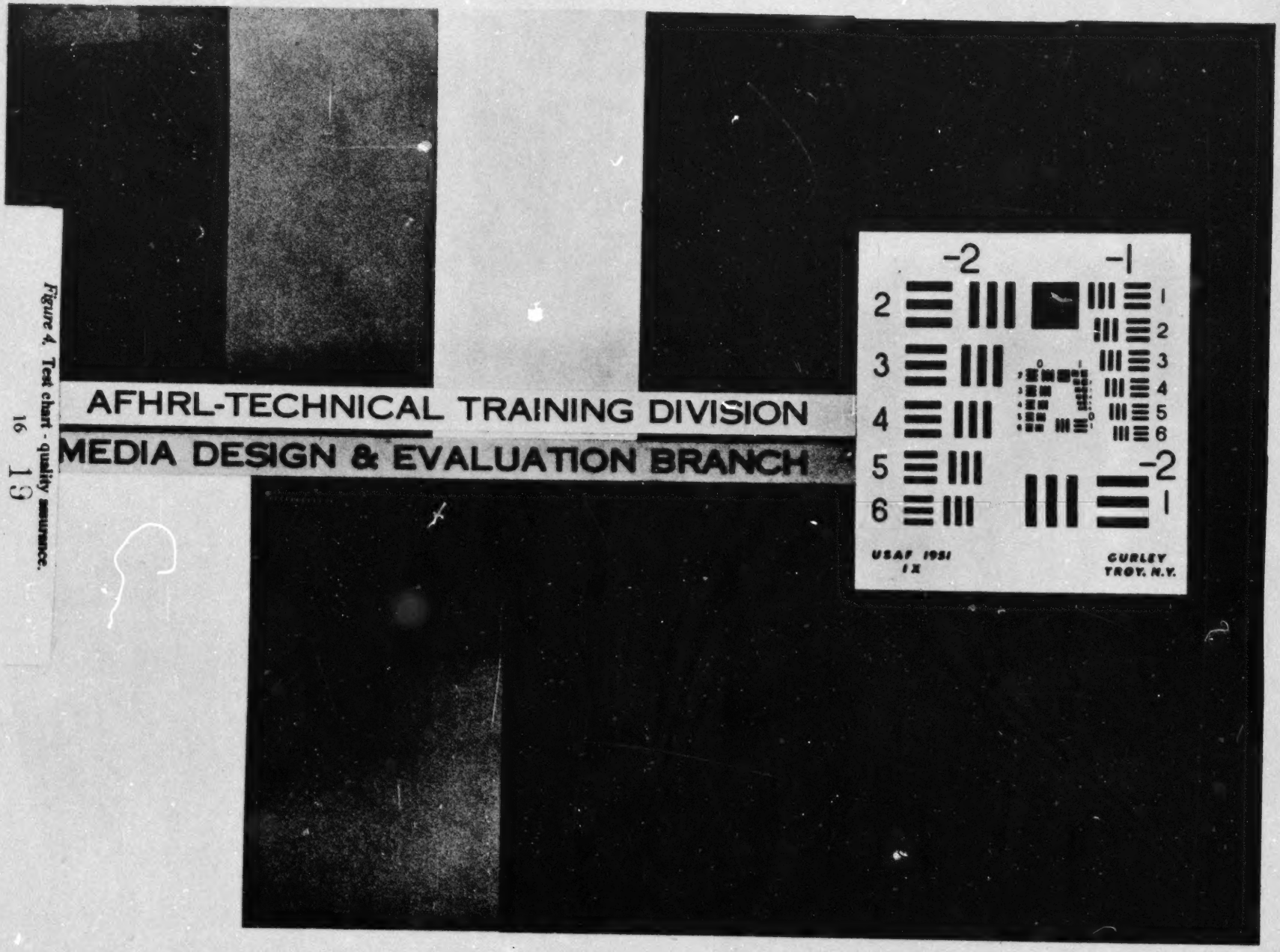


Figure 4. Test chart - quality assurance.

of Group 1 when projected in a carousel. For contract purposes it is suggested that at least set 2 of Group 1 be required. This is adequate yet well within the state of the art.

Gray scale. The bottom portion of the card is a series of grays that are roughly the same as the 1st, 4th, 6th, 8th, and 11th step of the conventional 13 step gray scale used in photography. The ones on our card have reflective densities of 0.09, 0.47, 0.77, 1.02, and 1.54 respectively. Each is also very even in terms of color balance averaging about 0.01 difference between white density and red, green, and blue densities (Table 3). The critical features are that the center gray should be cut from a 18% gray card such as those obtainable from Eastman. This reflects 18% of the light striking it. This is another way of stating that it has a reflected density of 0.75. This confirms the 0.77 value in Table 2. The other grays are not as critical and may be made from gray graphics material.

Table 3. **Empirically Determined Reflective Densities of Test Card**

	Gray Step				
Color of Light	1	2	3	4	5
White	0.09	0.47	0.77	1.02	1.54
Red	0.09	0.48	0.77	1.02	1.52
Green	0.10	0.48	0.77	1.01	1.54
Blue	0.10	0.52	0.78	1.01	1.55

This 18% gray card is central to color photography. It is used in controlling everything from the Kelvin temperature of lights to the replenishment of the developers. It is used here to determine exposure (density) and color balance.

The other critical feature is the ratio between the 2nd and 4th gray. The difference between these two establishes contrast ratio and in turn gamma. In our test card this difference is 0.55 (the 2nd has a reflected density of 0.47, the 4th is 1.02). Since the densities are in logs this difference determines a ratio.

Density. When this card is photographed and the resultant slide evaluated with a digital densitometer, several useful measurements can be obtained in a few seconds. First, the density of the middle gray value should be between 1.20 and 1.45 if the slides are to be projected for group viewing on a front projection screen. For use in a carrel with a rear projection screen, this value would be 1.45 through 1.70. These are average values for the projection system in a typical carrel. This "typical" system is considered to be an AF2 projector with a 250 watt ENH lamp, one front surface or mylar mirror, and a Polacoat LS60P1 1/8 in. screen in a room with 40 fc illumination on the work surface. When it is known that the ambient light or projection system will differ markedly from this "typical" system, the values should be adjusted accordingly.

Color balance. The color balance of the slide can also be determined from this 18% gray. This is done by measuring the red, green, and blue densities. These should approximate each other but there are so many variables involved that you can probably anticipate variations between colors of 0.10. Any difference greater than 0.30 would be objectionable. In a contract, the suggested limits are less than 0.20 desirable and 0.30 mandatory.

Contrast. The evaluation of contrast is equally important but a little more difficult to explain. All density measurements are logarithmic. Briefly, a slide with a density of 0 transmits all light, one with a density of 0.30 transmits 50% of the light striking it, a density of 0.60 transmits 25%, a density of 0.90 transmits 12.5%, a density of 1.00 transmits 10%, a density of 2.00 transmits 1% etc. (Density is the $\log_{10}$ of the reciprocal of transmission). The MacBeth people made the digital densitometer to eliminate manual measurements. You just record the numbers on the screen. All of this is to lead up to defining "contrast ratio." This is the ratio between the density of a light gray such as the second step in our gray scale and a darker gray such as the fourth step. Since the densities are expressed in logs, ratios are computed by subtraction rather than division. On our card, the second step has a reflected density of 0.47 and the fourth a reflected density of 1.02. The difference is 0.55 which is the contrast ratio.

You might have noticed that when a slide is duplicated the light parts appear lighter and the dark parts appear darker. After the third or fourth generation, all that is left is very dark and very light colors. The faces are chalky white and the blue uniforms appear black, etc. It is this increase in contrast that we are attempting to avoid. Gamma is used to express this increase. If a slide reproduces densities as they exist in

the object being photographed then gamma is 1.00. If the differences are diminished, then gamma is less 1. If the differences are accentuated, then gamma is greater than 1. For Kodak Ektachrome X Film, gamma is about 1.5. This means that differences are increased. The contrast ratio of 0.55 in the test card when photographed with Ektachrome X will give a contrast ratio of about 0.83 (0.55 X 1.5) on the resultant slide. In reality this is the value we do obtain on original slides made of the test card. However, when this slide is duplicated this increases to 1.25 (0.83 X 1.5). This is not objectional and in fact is often an improvement over the original if there are no dust marks or other defects and if flesh tones are not required. However, when this dupe is duplicated, the contrast ratio increases to 1.88 (1.25 X 1.5) which is not acceptable.

In this way, we are able to control the number of times a slide is duplicated and likewise the contrast ratio within them. We require that such a test image be photographed as the first image in any sequence. When this sequence is duplicated we can evaluate the test slide and have objective measurements to use. We require that the contrast ratio in this image be under 1.40. If different gray values are used on the test card, the mathematics have to be redone but the technique remains the same.

Empirical data. Table 4 presents some empirical data to illustrate the use of the test card.

Table 4. **Data from Duplication of Test Card**

Source of Reading	Contrast Ratio	Density of 18% Gray				Resolution	
		White	Red	Green	Blue	Group	Set
Original Card Ar	0.55	0.77	0.77	0.77	0.78	1	6
Original Slide	0.80	1.38	1.48	1.33	1.33	1	6
1st Generation Duplicate	1.37	1.31	1.41	1.25	1.26	1	4
2nd Generation Duplicate	2.02	1.34	1.42	1.28	1.26	1	2

The interpretation would be that the contrast ratio of the original slide was acceptable. The color balance is slightly out and it would be a little light for carrel use. The first generation duplicate of this slide would probably be accepted. The second generation duplicate, however, would be rejected. The contrast is too high.

The 2nd generation duplicate was also marginal in terms of resolution and unacceptable in terms of cropping. On the original slides, three lines could be distinguished through set 6 of Group 1. On the second generation dupe, this had deteriorated to set 2 of Group 1 which is the minimum acceptable. In terms of cropping, the initial words were cropped off of the 2nd generation duplicate.

It is apparent here that the unacceptable slide is unacceptable in many ways. This is usually the case and is a major justification of using such tests as those applied here. It is not that these characteristics are the only important ones but that they are the ones that are measurable and repeatable. Fortunately, they correlate highly with other desirable characteristics that are more difficult to measure.

Acceptable standards. On this test image then, we require acceptable cropping as indicated by the words in the center, resolution of Group 1 set 2, a density of 1.45 thru 1.70 (for individual instruction in carrels), and a contrast ratio of less than 1.40. These are all objective measurements that can be repeated by the contractor or processing lab.

AFIRL/TT assistance. If the initial shipment of slides is received prior to the establishment on the base of a quality assurance section with adequate test and evaluation equipment, it may be possible to have

samples tested by AFHRL/TTT. If so, it would be desirable to contact this organization to make specific arrangements. Point of contact:

AFHRL/TT
Lowry AFB, CO 80230
or 394-2954 (AV 926-2954)

VI. SUMMARY

The following summary may be appropriate for contract purposes.

Devices

A routine inspection should be accomplished of all devices as they are received. This should include consideration of suitability for classroom utilization, durability under student use, and maintainability including manuals and parts.

Cassettes and Film

A standard should be selected and used consistently. It is suggested that cassettes, recorded with a high quality recorder, have the capability of achieving a response of 100 through 8 kHz within ±3 dB, and a signal to noise ratio of 50 dB for a 1 kHz signal recorded at 0 dB with 1 volt rms input. Harmonic distortion at this level should be less than 3%. Physically it should be the equivalent of Scotch AVC-60. Film should be the equivalent of Ektachrome X for 36 exposure daylight cassettes, Eastman 5242 or 5256 for original copy work, and Eastman 5038 for duplication. Suitability for USAF processing is essential. The selected film and tape should be used throughout the program.

Audio

Audio should be received on 1/4 in. masters recorded half track at 7.5 ips and accompanied by typed scripts that indicate impulses. Reference tones placed at the end of each tape should include 30 seconds of white noise and 30 seconds of 1 kHz. These should indicate a 100 through 7 kHz response range with less than 3% deviation in speed, less than 2% 2nd and 3rd harmonic distortion, less than 1% rms flutter, and a signal to noise ratio of at least 50 dB.

Visuals

The visual packages should be submitted in the form of 8 X 10 in. captioned photos. It should include a test chart that provides for the determination of density and color balance of an 18% gray card, contrast ratio, resolution, and cropping. Values of slides made from the test card should indicate a density of 1.45 through 1.70, resolution of Group 1, Set 2, a contrast ratio less than two and one-half times that of the art, color balance preferably within 0.20 and required to be within 0.30, and cropping to indicate that at least 85% of the original art is included in the slide.

Implementation of Program

The costs of implementing a quality assurance program would depend primarily on the equipment and manpower available on the base. Once a program is implemented, the cost of operating it is very small; the savings are great. The initial equipment required specifically for this task would be the equivalent of Mincom 6500, Recorder Test Set and a digital densitometer such as the MACBETH TD-504 with status A filter head. Each costs $1,500 to $2,000. Both are standard laboratory apparatus and would be integrated with similar base equipment. No formal training of using personnel would be required nor would any particular AFSC be required to operate it. (It is assumed that such standard test equipment, as voltmeters and oscilloscopes with storage capability, are available.)

Assistance in Starting

If it is not possible for the receiving base to have a quality assurance program in operation when the contract is initiated, arrangements could probably be made with other USAF bases that do. For example, arrangements for at least temporary assistance could probably be worked out with AFHRL/TT, Lowry AFB or through Hq ATC with Training Services Division, Lowry AFB.

REFERENCES

AF Manual 50-2. *Instructional system development.* Washington: Department of the Air Force, 31 December 1970.

ANSI PH7.4. *Fifth draft proposed American National Standard for audio-visual and educational use of co-planar magnetic cartridge, Type CPII (compact cassette).* American National Standard Institute, 1430 Broadway, New York, NY 10018, January 1974

Smith, E.A. *Acceptance inspection for audio cassette recorders.* AFHRL-TR-74-101, AD-A011 618. Lowry AFB, Colo.: Technical Training Division, Air Force Human Resources Laboratory, December 1974.

Smith, E.A., Hall, P.W., & Manson, J.B. *Techniques for generating instructional slides.* AFHRL-TR-75-68. Lowry AFB, Colo.: Technical Training Division, Air Force Human Resources Laboratory, November 1975.

Sullivan, D.J., Smith, E.A., & Filinger, R.H. *A survey of the present state-of-the-art in learning center operations.* AFHRL-TR-74-11, AD-776 776. Lowry AFB, Colo.: Technical Training Division, Air Force Human Resources Laboratory, February 1974.

Van Cott, H.P., & Kinkade, R.G. Human engineering guide to equipment design. In L.L. Beranek, The design of speech communication. *Proceedings of the institute of radio engineers,* 1947, **35**, 880.

APPENDIX A

CAPTIONED PHOTOS AS A PRODUCTION TECHNIQUE

A survey of learning centers conducted by Sullivan, Smith, and Filinger (1974) for the USAF indicated that while courseware production was a major problem with most centers, few had developed specific techniques for such tasks as the initial preparation of visuals and the later updating or revision of the visuals. In general, the adoption of a learning center creates a demand for visuals that greatly exceeds the normal production levels. Two methods of meeting this increased need were observed. These will be referred to here as "Standardized Graphics" and "Graphics with Duplicate Slides."

In such programs as the DC-10 training program done by the aircraft manufacturer, a specific graphics production unit was created to meet this need. The program involved only one basic topic, the crosstraining of DC-10 flight crews. This allowed the firm to design very standardized images. Specific colors, papers, and lettering fonts were designated for use on questions, answers, instruments, gauges, push button, etc. They were also able to print the various instruments and dials so that the artist could create such re-occurring images as an altimeter by pasting a dial on a print of the altimeter. Every image in the final package was prepared on standard sized "Art Board" and then copied on 35 mm film. It is estimated that with these simplifications it took about 3.5 man-hours to produce a visual.

The second method of producing the visuals observed in the centers depended heavily on duplication of existing 35 mm slides. On the average, about 40% of the images were obtained in this way with the remainder being prepared graphically. Often the graphics would be created from plaster of paris or plastic letters that required lettering the graphic, photographing it, and then re-using the letters for the next graphic. As a result, if the image had to be rephotographed, the entire procedure had to be repeated. Other graphics were prepared in a conventional manner but seldom was an effort made to use a uniform size.

While the second technique is somewhat faster and less expensive than using all graphic material, updating the program is difficult. Of the 28 learning centers visited, only two reported that they could routinely update a prenarrated slide program. Most reported that keeping the material current was a major problem. Even after a validated package is created, a considerable number require revision due to changes in the subject matter material, i.e., the equipment or activity being taught changes requiring a parallel change in the training material.

One style of preparation that holds promise in terms of ability to update or revise content is called "Captioned Photos." This method requires that all images be prepared on uniform 8 X 10 size card stock. However, unlike the DC-10 system, it relies heavily on photography and makes a concerted effort to use 35 mm single lens reflex cameras to generate as many of the images as possible. For example, in a step-by-step procedure, each step is photographed using a 35 mm camera with interchangeable lenses such as the Nikon F. These negatives are enlarged to color or black and white prints. These prints are permanently bonded to a fairly heavy colored card stock. By adding a few words in a caption and an arrow or circle to highlight essential actions or parts, images may be created that combine the economy of the photograph with the clarity of the graphic. Usually, about 60% of the images in an instructional sequence can be prepared in this way.

Another 10% of the images can be prepared by photographically enlarging typed copy. This would include questions, crucial definitions, check list entries, and the like (Smith, Hall, & Manson, 1975).

It is often possible to obtain an additional 15% of the images by copying illustrations from manuals, texts, forms, checklists, or other instructional material.

Normally, there will still be about 15 to 40% of the images that are basically graphics and must be drawn. Some of these can be drawn to match the size requirement of the 8 X 10 inch card. Other images must be reduced or enlarged by using a copy camera. However, all graphics must be in the horizontal format and all must be matted on 8 X 10 card stock.

A peg registration similar to Acme is recommended to assure that all visuals are properly aligned. If overlay cells are used, the number should be limited to four and a platen glass used to hold the overlays flat for shooting.

With these captioned photos on hand, it is very easy to use them as a detailed story board during tryout and revision. They must be handled with care, touching only the outside edge were a one-inch border has been left for this purpose. The images that must be revised can be changed individually. Images

can be inserted or deleted at will. Minor changes within the captioning can be done. While it is usually desirable to have the images numbered, the numbers can be inserted by laying numbered tabs on the art during the final photography. Such number or other identification should be distinctive and in the same location on all frames within a series to avoid confusion with subject matter material. It is suggested that the very bottom half inch be used for production notes. This is outside the area photographed. Any unusual instructions the photographer needs can be placed on the right. A code number identifying the course, block, and frame should be on the left.

These procedures may be clarified by referring to Figures A-1, A-2, A-3, and A-4. They represent typical captioned photos matted on 8 X 10 card stock. It should be noted that it is the card stock on which the photo is mounted that is a standard size. The photo itself may be 8 X 10 or smaller with 4 X 5 and 5 X 7 sizes being common. With the smaller size photos the captions are generally placed adjacent to the photo rather than on it. The captions are very effective in developing step-by-step procedures. Highlighting or calling attention to details can readily be done by adding words, arrows, or circles to the print. Black and white photos on colored card stock with colored arrows or circles are particularly effective since color is reserved for directing attention to the essentials. The black and white print is somewhat cheaper than a colored print and usually takes less time. However, these differences are becoming less and less as newer color processes are developed. If a 4 X 5 polaroid back for a view camera is available, these polaroid prints can often be used, especially during revisions.

In the final photography, the first image is placed under the copy camera and carefully positioned in a holder. The area photographed is 5-1/4 X 8 in. to correspond to the 2 X 3 aspect ratio of a slide (24 X 36 mm). Additional bleed area is allowed at the top and bottom so that an area 6 X 8 in. can be photographed for filmstrip, video, or movies. Filmstrip has 3 X 4 aspect ratio (18 X 24 mm). This still allows an additional inch on all sides to provide for handling, bleed for video, and margin notes.

After the camera setup is complete and the holder affixed to the table, all subsequent images are made without requiring further camera adjustment. In this way, productions can be re-shot in a minimum of time. Leaving the additional bleed area at the top and bottom of the area photographed for a slide allows the slide art to be used for movies, TV, or more often to generate filmstrip. If only a few copies are needed, multiple copies of the filmstrip can be generated. If many copies are required it might be more economical to make a master and have duplicates made on a loop printer.

The essential feature of the captioned photo technique is that all images be uniformly placed on standard size mats. There may be some variation between lessons or packages, but within each uniformity is essential. The actual size is rather arbitrary. The 8 X 10 in. was selected since it is large enough so that much graphic work can be done on it, yet it is small enough that 35 mm photographic negatives can be used rather than requiring a larger size. If the art board is purchased in standard 30 X 40 in. sheets, it may be desired to cut these into 7-1/2 X 10 in. pieces to save waste. But again, within a lesson, all images are uniform.

The captioned photo technique has many additional advantages that become apparent as the program grows. The first is that it encourages the use of photographic techniques in coordination with graphic production. The camera (especially the 35 mm SLR with built-in exposure meter and interchangeable lenses) and the enlarger are amazingly creative tools when systematically employed. If the enlarger and camera are accepted as graphic tools, and photography and graphics are combined rather than being separated by outmoded procedures and regulations, much time and money can be saved.

A second advantage is that the final visuals can be duplicated with unexpected ease and quality. Duplicate slides can be generated from the original card art without the increased contrast resulting from slide duplication. Filmstrips can be updated by the change of individual images and re-photographed in a matter of minutes. The difficulty of updating filmstrip has been seriously *over* estimated. Successful duplication, however, does require standardized copy. Similarly, the difficulty of generating acceptable duplicate slide sequences from slides has been seriously *under* estimated. In large volume, the man-hours required to mount the slides and get them properly arranged in trays soon becomes overwhelming. The deterioration in quality is great.

A third advantage is that minor revisions can be made in the total sequence without a major redo. The developer can look at the finished card art and do some final polishing without introducing major costs or delays. It is similar to the difference between a typed copy and a printed copy. You might see a statement in a manual that you would like to re-write but it takes a lot of time and effort to change it after it has been printed. By contrast, a typed draft can be revised quite easily. In a similar way, individual pieces of card art

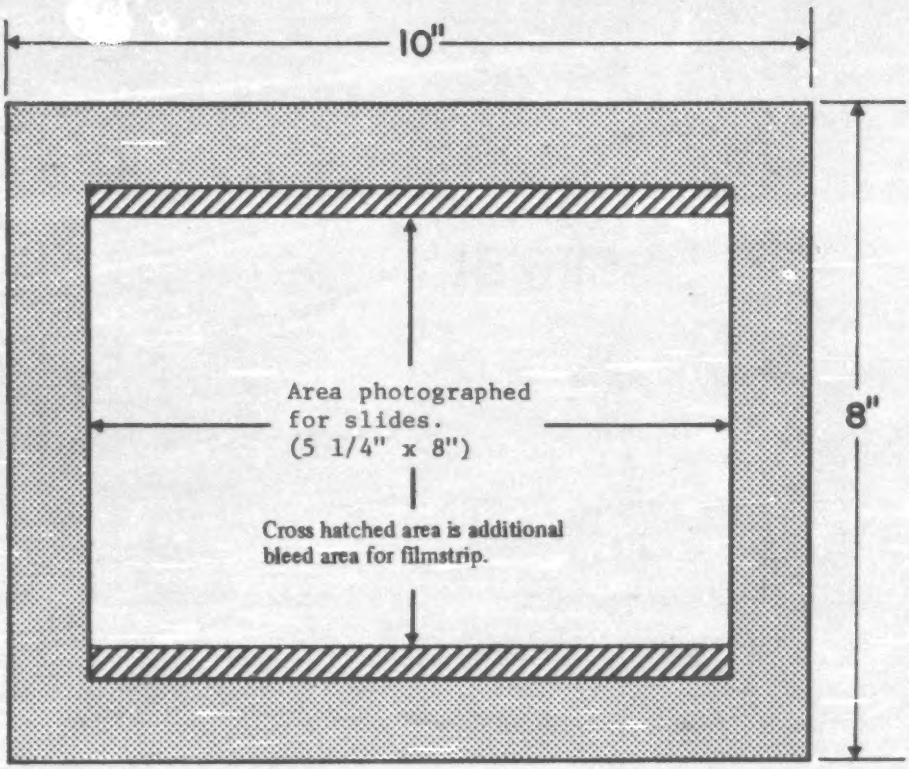


Figure A-1. **Basic format of 8 x 10 card.**

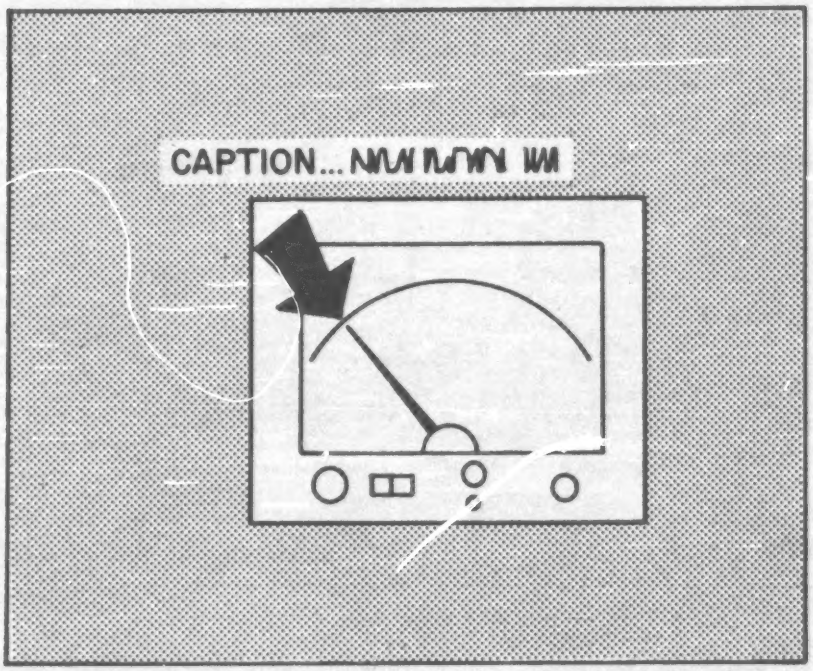


Figure A-2. **Caption and red arrow added to 4 x 5 black and white photo.**

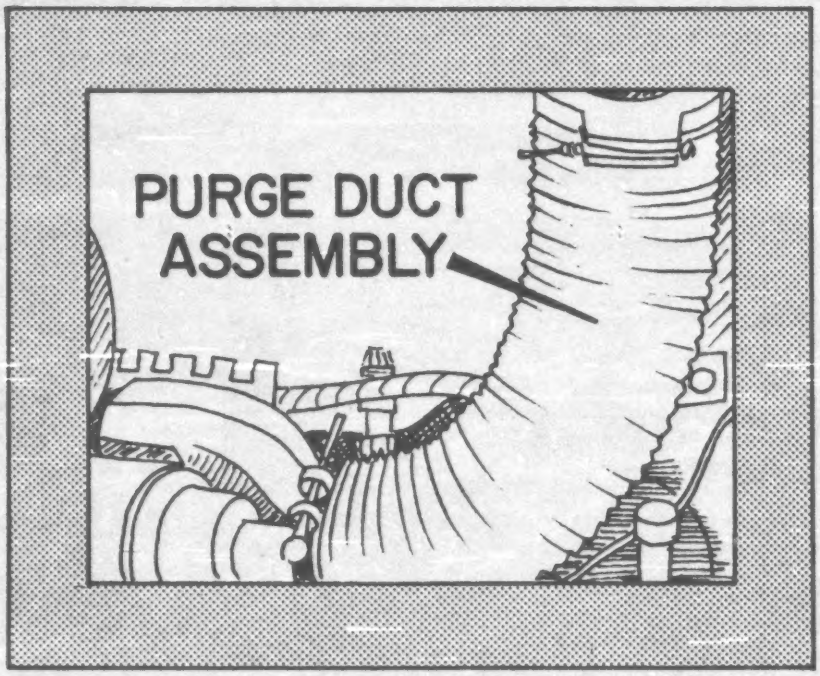


Figure A-3. **Lettering placed on 8 x 10 photo cropped to 6 x 8 or mounted full size.**

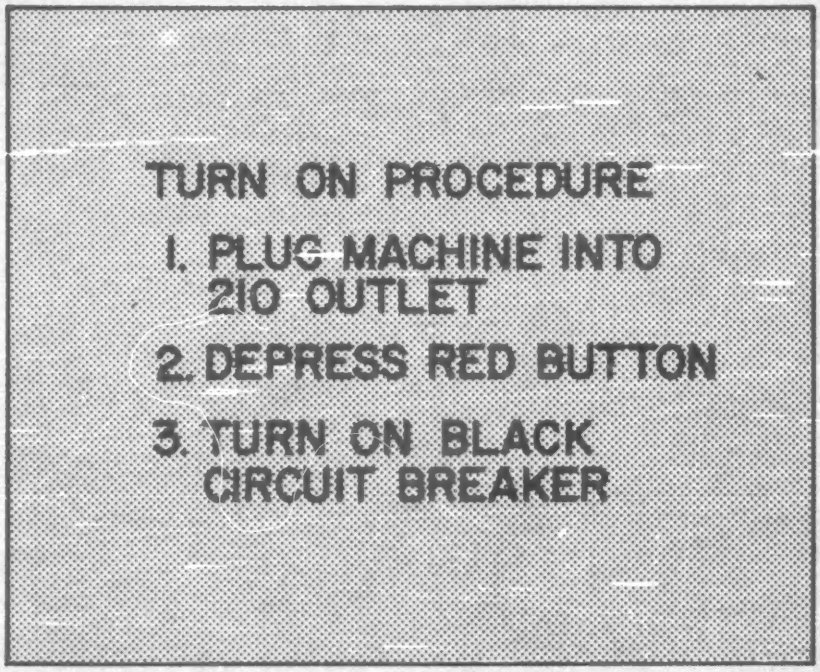


Figure A-4. **Lettering or photographically enlarged typed copy.**

can be revised much more readily than a completed package. All later revisions benefit doubly from this ability to change, add, or subtract individual images. It is very helpful to be able to survey the total sequence as a story board.

A fourth advantage in having every visual image developed in the form of standard size 8 X 10 card art is that it enables the development of the program in such a way that it can be produced as slides, 35 mm filmstrip, 16 mm filmstrip, or 8 mm filmstrip with equal ease. The same images may serve as a final story board for movies or TV. In essence, you can develop the program first and select the media later. You can also change from one medium to another at a later date with minimal additional effort. The slight difference in shape between slides and filmstrip is easy to compensate for.

As a rule, 35 mm slides are recommended as the developmental and prototype medium. They will also provide backup to other media. This selection is based primarily on availability of reliable equipment, ease of student operation, and ease of developing and revising initial slide sequences. Later, the sheer bulk of the courseware materials may become a problem. At this point, a conversion to filmstrip is recommended. If the 8 X 10 captioned photos are used initially, this conversion will not be a major task; without standardized copy it is virtually impossible, largely due to the difference in filming procedures. If ten copies of a slide sequence are required, the slides may be generated in any order and all ten copies of each image are made consecutively. If in doubt, shoot an extra one or two. By contrast, in a filmstrip, image one must be shot first, then the second, then the third; any error and you start over from the beginning. For the second copy, the process is repeated. With standardized copy it is easy, otherwise it is difficult. (How long has it been since you shot 72 consecutive good pictures with your personal camera?)

Sullivan's survey of learning centers revealed that very few centers had production costs that could be isolated from other operating costs. Two firms had projects large enough that the man-hours required to generate the graphics could be isolated. Both firms were producing literally thousands of graphics for one project and had established very systematic and efficient production techniques. One reported that on the average it required 3.5 man-hours for the production of each graphic. The other firm instituted a technique to utilize less experienced personnel. This resulted in lower costs per hour but required more hours. The costs per slide were almost identical. Both indicated that labor was by far the dominant cost and suggested that for comparative purposes, material costs be ignored and the emphasis placed on developing the most efficient method in terms of manpower costs.

There was no evidence that the centers using a mix of graphics and duplicate slides were able to produce the graphics in any less time. It was estimated that the duplication of slides probably took 0.1 hours or less. Since these centers averaged 60% graphics and 40% duplicate slides, the savings was nearly 40%.

When the captioned photo technique is employed, the costing is somewhat more complex due to the variety of skills required. This technique relies heavily on three assumptions: (1) a 35 mm camera is used for shooting, (2) the production team stays together until the production is completed, and (3) the tasks are aimed at defined terminal objectives and, as such, are performance oriented.

About 60% of these images consist basically of a mounted photo, usually 5 X 7 or 8 X 10. Most are captioned or highlighted and virtually all are numbered. In volume, these take about 0.3 man hours to produce. This is divided about equally between shooting, processing, and mounting. Captioning requires an additional 0.2 hours.

About 15% of the images are from original graphics. These still require the 3.5 hours to draw and this system adds another 0.2 hours for conversion to standard size card art.

About 15% are "text" images. They are shot from illustrations in texts, from forms, or checklists, etc., without major graphic revision. These are generated on the copy camera and take about 0.2 hours to shoot, process, and paste up. Most of these are black and white images.

An additional 10% of the images can be typed, then enlarged. These would be the questions, the crucial definitions, etc.

Summarizing this data and estimating for the production of 100 visuals:

a. Standardized Graphics Technique

Graphic time 100 X 3.5

Total time 350 hours

b. Graphics with Duplicate Slides

Graphic time	60 X 3.5 = 210 hours
Slides	40 X 0.1 = 4 hours

Total time 214 hours

c. Captioned Photo Technique

Captioned photos	60 X 0.5 = 30 hours
Graphics	15 X 3.5 = 53 hours
Conversion	15 X 0.2 = 3 hours
Typed	10 X 0.2 hours = 2 hours
Text	15 X 0.2 = 3 hours

Total time 91 hours

Field tests of the system indicate that these figures are about as close as can be expected. The time required varies primarily in accordance with volume and to equipment availability.

28 ☆U.S. GOVERNMENT PRINTING OFFICE: 1975- 671-502/8035